AD-A133 870 MINICOMPUTER ADMINISTERED TASKS IN THE STUDY OF EFFECTS OF SUSTAINED WORK ON HUMAN PERFORMANCE(U) NAVAL HEALTH RESEARCH CENTER SAN DIEGO CA D H RYMAN ET AL. AUG 83 1/1

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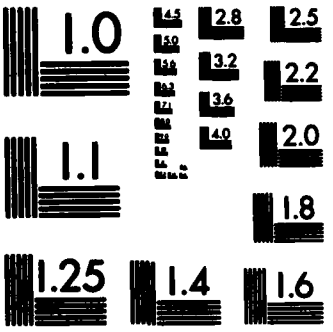

MINICOMPUTER ADMINISTERED TASKS IN THE STUDY OF EFFECTS OF SUSTAINED WORK ON HUMAN PERFORMANCE

D. H. RYMAN
P. NAITOH
C. E. ENGLUND

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NAVAL HEALTH RESEARCH CENTER
P. O. BOX 85122
SAN DIEGO, CALIFORNIA 92138

NAVAL MEDICAL RESEARCH AND DEVELOPMENT COMMAND
BETHESDA, MARYLAND

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David H. Ryman*
Paul Naitoh*
Carl E. Englund*

Naval Health Research Center
P.O. Box 85122
San Diego, CA 92138-9174

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*Environmental Physiology Department

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Summary

The measurements of changes in human performance during laboratory studies of long-term (sustained) continuous work periods has been greatly facilitated with the introduction of computer administered and scored tasks. This report documents six minicomputer administered tasks and their scoring programs which have been successfully used in the Sustained Operations research program at the Naval Health Research Center. The minicomputer system used in these studies was a MINC-11 (Modular Instrumentation Computer from Digital Equipment Corporation) configured with A/D converter and clock modules, two terminals and a printer. The tasks were selected for measurement sensitivity to sleep loss and fatigue. Four of these tasks involved measures of different types of reaction times. The TRAP task measured the response times of alternate pressing of two buttons; the Simple Reaction Time task recorded response times to a visual stimulus; the Alpha-Numeric Visual Vigilance task measured response latencies to correct and incorrect (disjunctive) visual signal detections, and the Four Choice Serial Reaction Time task measured reaction time involving correctness of choice to a visual stimulus in one of four areas on a terminal screen.

Two other tasks presented via computer were the Logical Reasoning Task, measuring correctness of complex information processing, and a Mood-Symptom-Fatigue and physiological state survey.

The task programs were written in assembly language (MACRO-11), and the scoring-listing programs in Fortran IV. The programs have been run on a MINC-11/03 and 11/23 computers, with two double-density disk drives.

Laboratory measurements of changes in human performance during continuous (sustained) work had been carried out before the wide-spread availability of digital computers. (Ecosystems, 1977; Hartman, Benel, & Storm, 1980 Kennedy, Bittner, Carter, Krause, Harbeson, McCafferty, Pepper and Wiker, 1980; McKenzie, White & Hartman, 1969; Moran & Mefferd, 1959; Morgan, Brown, & Alluisi, 1974; Naitoh, 1981; Opstad, Ekanger, Nummestad, & Raabe, 1978; Reilly & Cameron, 1968). Computer administered testing has made the presentation of tasks and collection of data in the study of the effects of sustained work more easily accomplished (Angus, Innes, & Pearce, 1980; Eckerman, D.A., 1981; Englund, Naitoh, Ryman, & Hodgdon, 1983; Heselgrave & Angus, 1983; Mullaney, Kripke, Fleck, & Johnson, in press; Olson, Moeller, & Laxar, 1973; Naitoh, Englund, & Ryman, 1982; Thorne, Genser, Sing, & Hegge, 1983).

The purpose of this paper is to describe a series of computer presented tasks that have been used successfully in studies of the effects of exercise and sleep loss resulting from sustained work on human performance. These programs have been successfully used in studies involving 48 pairs of U.S. Marine Corps subjects.

METHODS

Measures

Tasks were selected on a priori basis for sensitivity to the effects of sleep loss and fatigue (e.g., Williams, Lubin, & Goodnow, 1959; Wilkinson, 1964). Three of these tasks correspond to Donder's three reaction time measures: Simple Reaction Time (SRT: stimulus detection followed by response), Disjunctive Reaction Time (DRT; stimulus detection followed by sensory discrimination and response), and Choice Reaction Time (CRT; correct choice or motor selection added to DRT) (Grice, Nullmayor, & Spiker, 1982; Companion & Corso, 1982). The fourth task primarily measured motor response speed and consistency, and the fifth task representing complex information processing were also incorporated into the computer administered test battery. Along with these tasks the computer surveyed moods, physical symptoms, fatigue and physiological status of volunteer subject (i.e., oral temperature, blood pressure and grip strength).

Designs

The experimental designs for studies of long, continuous "sustained operations" (SUSOP) have called for hourly to every 3 or 4-hour repeated use of all or some portion of these computer administered task batteries. The results of studies applying these tasks have been published (Naitoh et al., 1982; Englund et al., 1983). The experimental designs of the studies have varied the physical workload levels of the experimental subjects as well as the length and type (nap-no nap) of rest between continuous work cycles. What follows is the description of the computer system, the task programs and data and scores generated in these studies. Table 1 summarizes types of tasks, task names, and performance measures used in the SUSOP studies.

System

Six tasks were presented, using a MINC-11/23 (Modular Instrumentation Computer; Digital Equipment Corporation, DEC). This computer was configured with an A/D converter (MNCAD) and programmable clock (MNCKW) modules. It consists of a LSI 11/23 processor with 128K RAM, two laboratory module interfaces, two dual density floppy disk drives (RX02s), and an interactive terminal (VT105). The present study also utilized three other peripherals: a second terminal (VT100), a printer (LA120), and a slave CRT monitor. The programs for administering six tasks were written in assembly language (MACRO-11). The computer operating system used was RT-11 Single Job (Version 3 and 4). The raw data listing and scoring programs were written in FORTRAN IV (Version 2.5).

Table 1. Task Types, Names and Measures

Type of Task	Task Name	Measures - Scores
Motor Reaction Time	Tapping Task	# responses each minute, 10% fastest, 10% slowest; means and SDs, # lapses
Simple Reaction Time	Simple Reaction Time	60 reaction times, 10% fastest, 10% slowest; means and SDs, # lapses
Disjunctive Reaction Time	Alpha Numeric Visual Vigilance Test	Reaction time of correct responses, errors of commission, means and SDs, # omissions
Choice Reaction Time	Four Choice	Reaction times, correct or incorrect; means and SDs, 10% fastest, 10% slowest, # and % incorrect responses
Complex Information Processing	Logical Reasoning	Questions given, responses, # correct, # incorrect, % correct, # questions answered
Mood Symptoms, Fatigue	Mood-Physiology	POMS scales, NHRC scales, blood pressure, oral temperature, grip strengths, KOGI physical symptoms, SAM Subjective Fatigue Scale, SSS

Program Execution

Two volunteer subjects from the U.S. Marine Corps were tested simultaneously. The experimental subject was required to walk on a treadmill a half hour of every hour of testing. The control subject remained seated in a chair in front of a monitor. The task programs were called by the control subject when he keyed in on a VT105, a simple "run" command (i.e., press an "R" of a terminal keyboard), typed in a task name, then responded to a prompt asking for a session number; some of the tasks require a "T" to start. Outputs from each task were stored on the disk unit 1 of the RX02. Three data diskettes were needed to store data from a week-long study involving two volunteer subjects, each diskette having 17 session files of 19 to 26 blocks each. Prior to data collection, diskettes were formatted, initialized, and the directory set up using a short assembly language program to accept outputs from the computer.

All the listing-scoring programs for data output were similarly called by keying in an R, a task scoring program name, and followed by responding to prompts for file name, team number, session, and day numbers. The storage requirements for these task programs, listing-scoring programs, the operating system and file creation programs are listed in Table 2.

TASK DESCRIPTIONS

Task of Response Alternation Performance (TRAP)

This tapping task, designed by Humphreys and used by Friedman, Globus, Huntley, Mullaney, Naitoh and Johnson (1977), and Naitoh et al. (1982), consists of a "box" with two one-inch buttons. This task primarily measures motor speed and consistency of reaction time over 6 minutes. The output of this box (a 5-volt TTL signal) was connected to an A/D converter module on the computer. With their eyes closed, volunteer subjects pressed one of two buttons alternatively at as steady a pace as they could with the first digit of their dominant hand. If alternate buttons were not pressed in 2.5 seconds, a bell sounded to alert the subject. The inter-response intervals are recorded over a period of six minutes. At the end of six minutes a bell rings to indicate the end of the task. The number of button presses each minute for

Table 2. Floppy Diskette Storage Requirements for Compiled Programs and Data (Number of Blocks)

Task Name	# Blocks Task Program	K	# Blocks List/Score Program	K	# Blocks Stored Data Each Session	K
Alpha-Numeric Visual Vigilance Test	41	20	43	22	3	1.5
Moods - Physiology	17	9	28	14	2	1.0
Simple Reaction Time	7	3	33	17	1	0.5
Tapping Task (TRAP)	27	14	34	17	4	2.0
Logical Reasoning	9	5	30	15	2	1.0
Four Choice	14	7			8	4.0
File Setup	4	2				
Operating System	67	34				

256 bytes per block with either 436 blocks (single density) or 976 blocks (double density) on an 8-inch floppy diskette.

each subject was recorded on the output floppy diskette along with the 10% fastest and 10% slowest response times over the six-minute period. Performance measures of extremely slow or fast responses were used in this study as they have been shown to demonstrate the effects of sleep loss (Williams et al., 1959; Lisper & Kjellberg, 1972).

The scoring program listed the number of button presses per minute and the total number of presses over six minutes for each subject. Means and standard deviations for the 10% fastest and 10% slowest inter-response intervals, along with a number of attentional "lapses", i.e. 2.5 seconds with no response, were also printed out.

Visual Simple Reaction Time Task

The simple reaction time task, as initially developed using an auditory signal by Lisper and Kjellberg (1972), was modified for visual signal. The visual signal task has been used in sleep loss research to measure reaction time to a stimulus (Herscovitch and Broughton, 1981). It consists of 60 randomly spaced trials of clock ticks in 100ths of a second displayed on the terminal screen. Subjects are told to press any key on the keyboard the moment they see numbers (clock ticks) appear on the monitor. The clock ticks stop on the screen the moment any key is engaged, or at 250 (i.e., 2.5 seconds after the start) when a bell rings. The response time remains on the screen for 0.5 second proving instant feedback to the subject. Intervals between the 60 clock-tick presentations vary randomly from 1 to 11 seconds, the mean interval being 6 seconds.

The listing/scoring program lists all reaction times and computes the means and standard deviations for the 60 reaction times, the six fastest and six slowest, as well as the counts of number of responses less than 2.5 seconds and the number of response lapses.

Alpha-Numeric Task Visual Vigilance

The Alpha-Numeric visual vigilance task (Hord, 1979, Naitoh, 1981) was developed at the Naval Health Research Center to measure long-term visual vigilance. This task consists of presentations on the VT100 and a slave monitor, of random alphabetic characters or numbers at random intervals ranging between 6 to 14 seconds with a mean interval of 10 seconds. The number or character is 10 x 20 mm in size and remains on the screen for 10 msec. Subjects are instructed to press

a hand-held normally open push-button switch with their thumb every time an A or a 3 appears. Twenty A's and 3's are randomly mixed with 160 other characters and numbers given during this 30-minute task. The program measures response latencies. At the end of a 30-minute task, all reaction times in msec are stored on the output floppy diskette. Response times to non A's and 3's are errors of commission and are stored as two's complement. Omissions, no responses to an A or 3 in five seconds, are stored at 5000.

The Alpha-Numeric visual vigilance task is given by the computer to experimental subjects who performed the task while walking on a treadmill. Control subjects performed the task while seated in a chair. The computer is programmed to administer the visual vigilance task, store and record the spirometric readings of breath volume, oxygen consumption, and carbon dioxide production, VO_2 ml/kg. These physiological parameters are displayed on the VT105.

The listing/scoring program for the Alpha-Numeric task lists all responses during a 30-min session, the number of correct responses (button presses following an A or 3), the number of errors of omission, and the number of errors of commission. The means and standard deviations for the correct responses, five slowest correct and five fastest correct responses are also printed out, along with the percent correct detection. An error of omission is declared when responses to an A or 3 are not made in 5 seconds. In computing mean reaction time as well as five slowest responses, errors of omission are added as reaction times of 5000 (five seconds).

Four Choice Serial Reaction Time Task

This task was developed by Wilkinson (Wilkinson and Houghton, 1975). This task can measure a subject's reaction time involving correctness of response. It consists of presentation of a blinking "+" (plus sign) in one of four quadrants of a video screen. The subjects are told to press one of four keys on the terminal keyboard which corresponds with one of the quadrants on the screen. The blinking "+" remains in a quadrant until one of the four keys is pressed, then randomly reappears in one of the quadrants. If none of the four buttons is pressed within 2.5 sec, a bell rings at 0.1-second intervals until a response is made. This task lasts six minutes and the subjects are instructed to respond as accurately and quickly as possible. Reaction times of all responses are recorded on floppy diskettes in 100ths of a second. Incorrect (wrong quadrant) responses are recorded as two's complement, and lapses as 250 (i.e., 2.5 seconds). This task is sensitive to sleep loss effect (e.g., Glenville, Broughton, Wing, & Wilkinson, 1978).

The listing/scoring program calculates the means and standard deviations for all correct responses, the 10% fastest and 10% slowest correct responses, the incorrect responses, and counts of number correct and incorrect responses, lapses, and percent correct responses.

Logical Reasoning Task

This task was devised by Baddeley (1968) to measure complex information processing. It consists of random presentation on a video screen of one out of 16 sentences followed by a pair of letters (AB or BA). Subjects are told to type a "1" if the sentence is a true description of the letter pair (i.e., "A follows B" BA)., or a "2" if the sentence incorrectly describes the letter pair (i.e., "A is preceded by B" AB). After the subject types a 1 or 2, that response is displayed next to the sentence letter pair. If the subjects change their minds about this response, they can delete the response and retype a 1 or 2. If the subjects think that their response is correct, they enter this response by depressing the ENTER or RETURN key, at which time the next sentence-letter pair appears. At the end of this 3-min task, the number codes for the sentence-letter pairs given and the subjects' responses to each sentence-letter pair attempted are stored on the output floppy disk.

The listing/scoring program counts the number of sentence-letter pairs attempted, the number that are correct, and calculates the percent correct. Another program used for a period of familiarizing and training for subjects prints all the questions, the subject's answers, and the correct answers.

Measurements of Mood, Fatigue and Physiological Status

This program is a series of mood and physical symptom questionnaires with instructions followed by prompts asking the subjects to enter readings of oral temperature, blood pressure and grip strength. The program stores the responses on floppy diskettes. The first questionnaire presented is the Profile of Mood States (POMS; McNair, Lorr and Droppleman, 1971). The 65 items in the questionnaire appear singly on the video screen and with the instructions on how to use the four-point response scale, entering or deleting their response to each item. Subjects press a numeric key corresponding to how each item describes his mood, followed by the Enter or Return key on the terminal to record his response. A subject can change his response before it is entered by pressing the delete key and entering a new response. Only after pressing a response value within the correct range and the Return or Enter key, is the response stored and the next item then appears.

After the POMS, the School of Aerospace Medicine (SAM) Subjective Fatigue Checklist instructions and its 10 items (Pearson and Byars, 1956; Naitoh, 1981) are presented in a similar manner. The next questionnaire is the 29-item Naval Health Research Center (NHRC) Mood Questionnaire (Moses, Lubin, Naitoh, & Johnson, 1974; Opstad,et al., 1978, found it to be sensitive to sleep loss and fatigue), which is followed by the 30-item KOGI Symptom Checklist (Kogi, Saito and Mitsuhashi, 1970; Englund, et al., 1983). For all these questionnaires, the instructions on use and recording of responses remains on the screen, and one item is presented at a time.

Following these questionnaires, subjects are asked to enter their oral temperature, their diastolic blood pressure, and grip strength of left and right hands, as measured with a hand dynamometer. The Stanford Sleepiness Scale (SSS; Hoddes, Zarcone, Smythe, Phillips and Dement, 1973) is the last request for a response.

The upper and lower ranges for these physiological data are checked when entered and out of range values are not stored, but cause a comment to appear, then a redisplay of the prompt requesting the input of that physiological datum.

When the last subject has entered a valid response to the SSS, all the values to the questionnaires and other variables are stored out on diskette with the time of day (in ticks of 100th seconds since midnight) at which the last value was entered.

The scoring program computes the scores of six scales in the POMS, the total score for the SAM Subjective Fatigue Checklist, the negative and positive scales on the NHRC Mood Questionnaire, and the total "Yes" answers to symptoms on the KOGI. The oral temperature in both Fahrenheit and Celsius, the systolic and diastolic blood pressures, and left and right hand grip strengths in kilograms, and the SSS responses are also printed out, along with the team, session, day file name, subject information, and time at which the task ended.

SUMMARY

All scoring programs analyze every session with the data from one disk. There is an option to output all scores to disk to facilitate transferring data to a computer system where the data are analyzed. Other scoring programs produce session means each day for the experimental and control subjects. The scores generated by these programs can also be stored on sloppy diskettes and the contents of these scores can be transferred to IBM or VAX computer systems for further statistical analyses.

These programs have been run on a MINC 11/03 and 11/23 with clock (MNCKW) and A/D converter (MNCAD) modules with VT105 and VT100 video display terminals. The scoring programs require a printer, LA120, connected to SLU port 2 on the MINC.

Listings or floppy diskette copies of the task or scoring programs can be obtained by writing to the senior author at the Naval Health Research Center. Requests for floppy diskette copies must be accompanied by a blank soft-sectored (SS/DD) 8" diskette.

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MINC 11		

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

Computer administration of tasks during laboratory studies of human performance changes in continuous work has made data collection and analysis easier and quicker. Six tasks and scoring programs were developed for the MINC 11 (Digital Equipment Corporation's Modular Instrumentation Computer) with an A/D converter and a clock module. Four of these tasks measured different types of reaction time; the TRAP task measured the response times of alternate pressing of two buttons, the Simple Reaction Time task recorded response

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20. Abstract (continued)

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